ARITHMETIC INSTRUCTIONS

UNCLASSIFIED

RISK ASSESSMENT:

Low

SAFETY CONSIDERATIONS:

Electrical Shock Hazard

Electrostatic Discharge

ENVIRONMENTAL CONSIDERATIONS:

None

TERMINAL LEARNING OBJECTIVE

ACTION: Explain how arithmetic instructions are used in microprocessors.

CONDITIONS: Given a classroom environment, Compute
Aided Instruction (CAI
workstation, and official
OMEMS reference material.

STANDARDS: Correctly answer 18 of 25
questions on how
arithmetic
instructions are used in
microprocessors.

ENABLING LEARNING OBJECTIVE

ACTION: Explain how double-precision arithmetic instructions are used in microprocessors.

CONDITIONS: Given a classroom environment, Compute Aided Instruction (CAI workstation, and official OMEMS reference material.

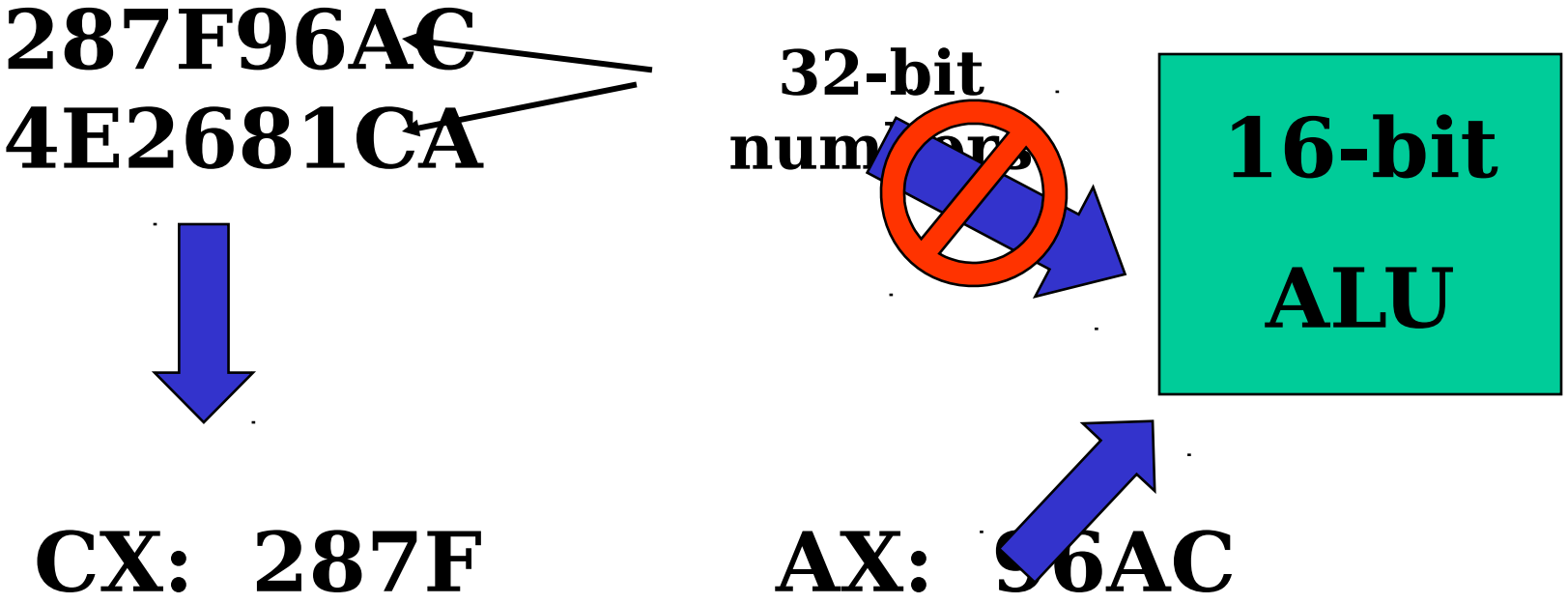
STANDARDS: Correctly answer 18 of 25 questions on how arithmetic instructions are used in microprocessors.

DOUBLE PRECISION ADDITION AND SUBTRACTION

Double-precision arithmetic allows the 8086 microprocessor to add (or subtract) 32 bit numbers using a 16 bit ALU.

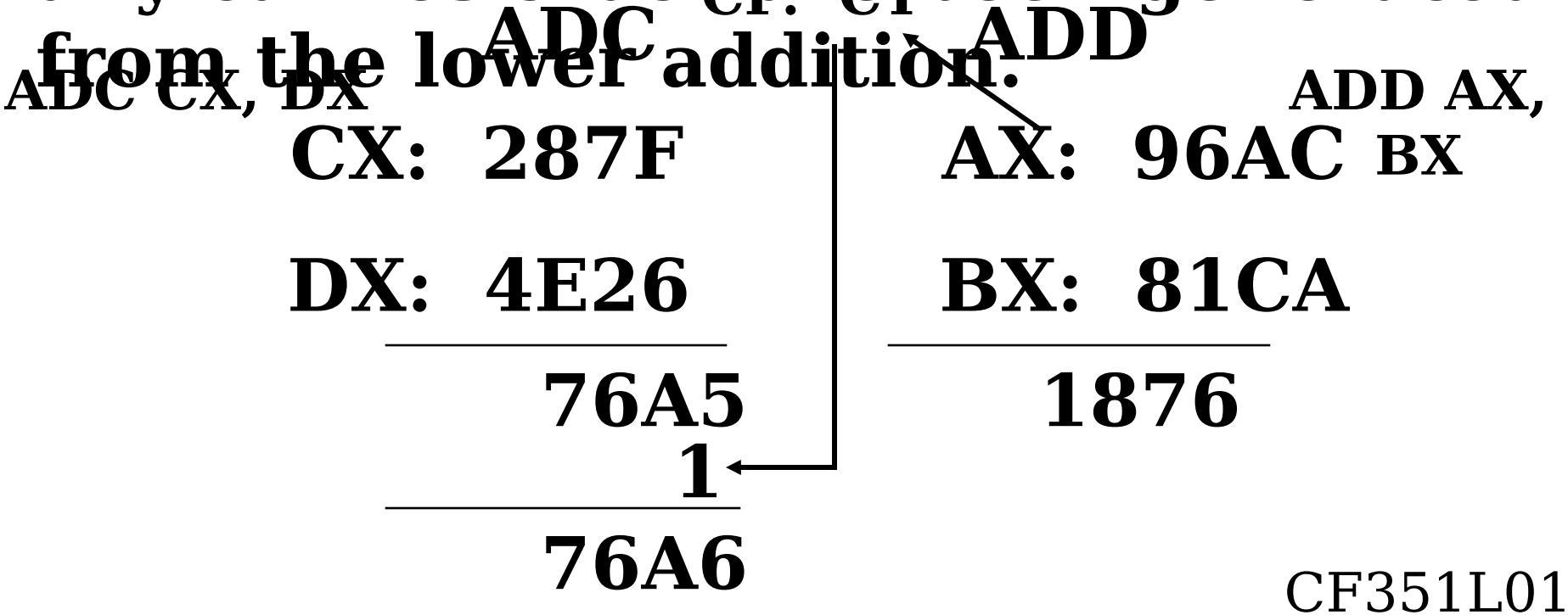
DOUBLE PRECISION ADDITION

The first step is to divide the 32-bit numbers into four 16 bit words in order to add them since the ALU is only 16 bits..



DOUBLE PRECISION ADDITION

The second step is the lower words are added then the higher words are added using the add with carry command that will take into account any carries that have been generated from the lower addition.



DOUBLE PRECISION ADDITION

The third step is the final answer is then stored in the two destination registers.

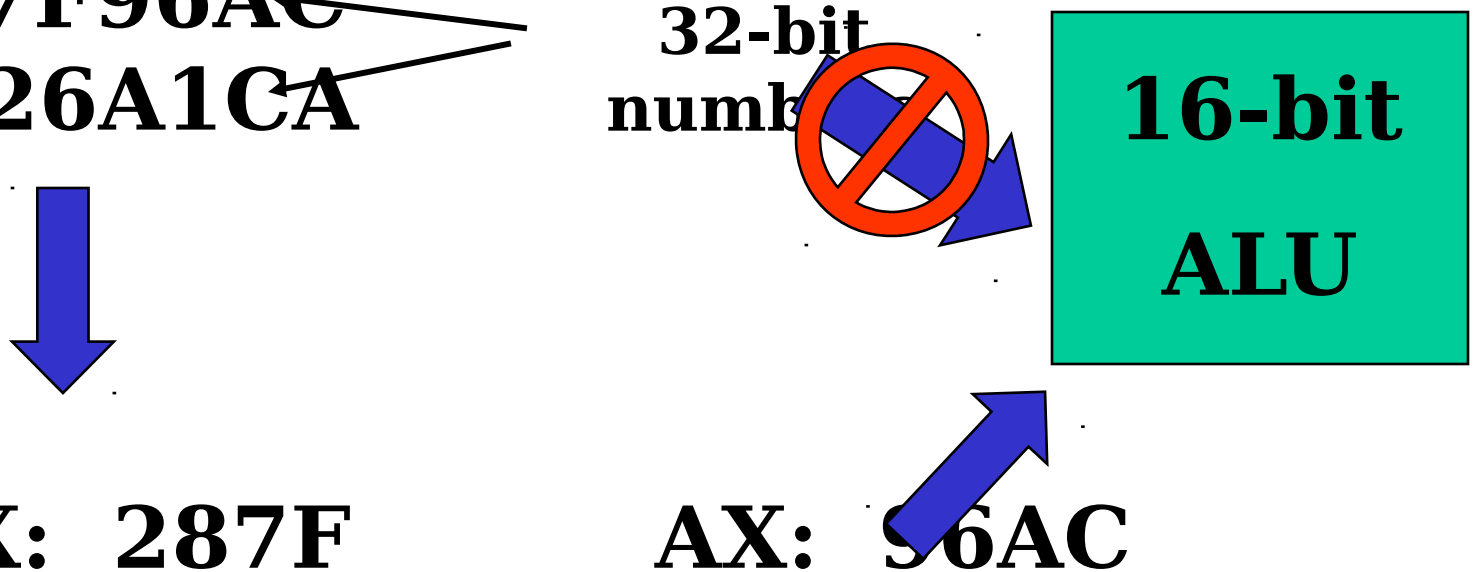
CX: 76A6 AX: 1876

DOUBLE PRECISION SUBTRACTION

DOUBLE PRECISION SUBTRACTION

The first step is to divide the 32-bit numbers into four 16 bit words in order to subtract them since the ALU is only 16 bits..

287F96AC
1E26A1CA

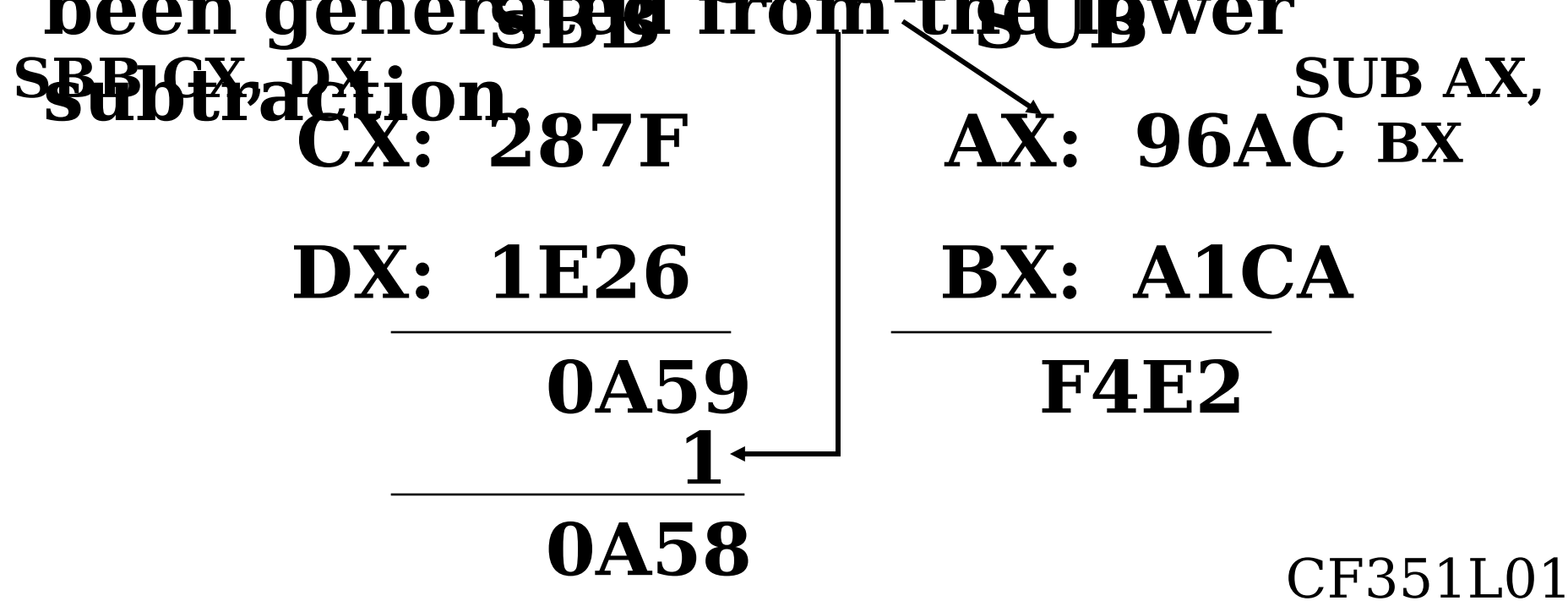


CX: 287F **AX: 96AC**

DX: 1E26 **BX: A1CA**

DOUBLE PRECISION SUBTRACTION

The second step is the lower words are subtracted then the higher words are subtracted using the subtract with borrow command that will take into account any borrows that have been generated from the lower subtraction.



DOUBLE PRECISION SUBTRACTION

The third step is the final answer is then stored in the two destination registers.

CX: 0A58 AX: F4E2

QUESTION

What are the three steps required when we add 32 bit numbers with the 8086 processor?

ANSWER

1. Divide the 32 bit numbers into 16 bit

   words.
2. ADD the low order words.

   ADC (Add with carry) the high order

   words.
3. Store the answer in the two destination registers.

QUESTION

Why use an SBB (Subtract with borrow) command when a high order word is subtracted in a double-precision subtraction problem?

ANSWER

To correct for any borrows that occurred from the subtraction of the low order words.

ENABLING LEARNING OBJECTIVE

ACTION: Explain how microprocessors convert between signed decimal numbers and signed binary numbers.

CONDITIONS: Given a classroom environment, Computer Aided Instruction (CAI) workstation, and official CMEMS reference material.

STANDARDS: Correctly answer 18 of 25 questions on how arithmetic instructions are used in microprocessors.

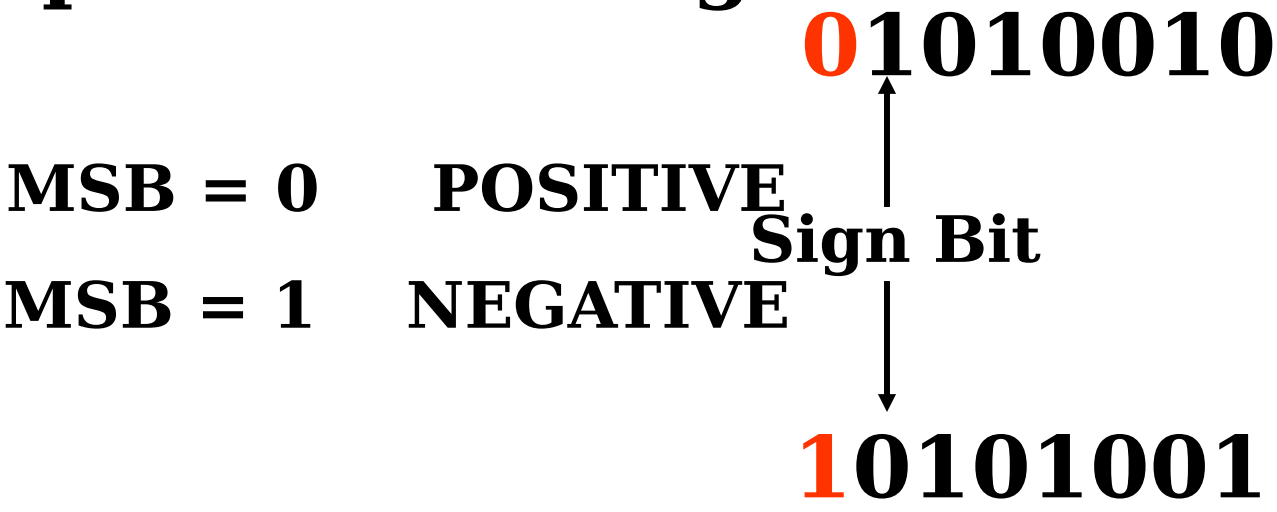
SIGNED BINARY NUMBERS

The method by which the binary code for a number can contain information as to whether the data is positive or negative is called signed binary.

This method uses the MSB of a number to indicate the sign of a number. The remaining bits are used to indicate the value of the number.

SIGNED BINARY NUMBERS

The MSB is the sign bit. It indicates whether the number is positive or negative.

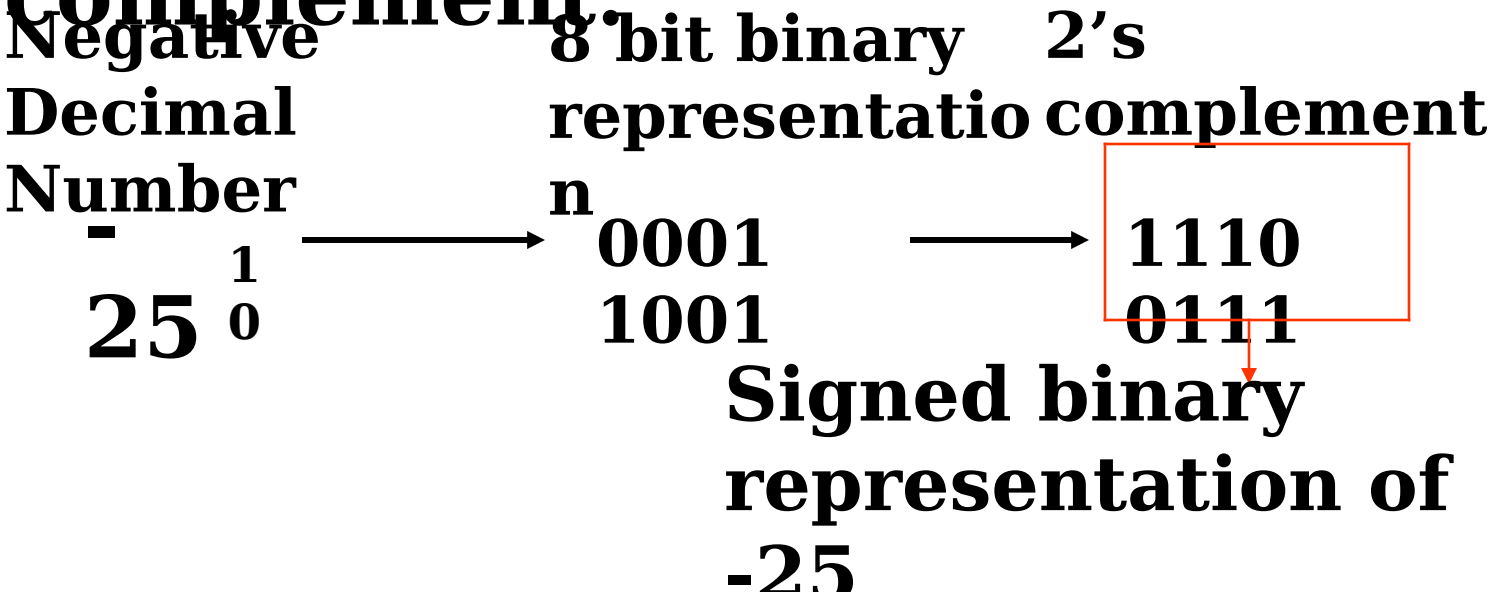


SIGNED BINARY NUMBERS

Signed binary numbers are used to represent a negative decimal number to the computer. This negative number can be used for a negative displacement (backwards jump) in a jump command.

SIGNED BINARY NUMBER CONVERSION

To convert a signed decimal number to a signed binary number the decimal number must be converted to an 8 bit binary number and then take the 2's complement.



Question

What is the signed binary equivalent of -75_{10} ?

Answer

Decimal Number → **-75_{10}**

8 bit binary equivalent → **010010_2**

11

2's complement → **10110_2**

101

Signed Binary Number

QUESTION

What procedure is used to convert negative signed decimal numbers to negative signed binary numbers?

ANSWER

Two’s complement.

QUESTION

What is the MSB of a negative signed binary number?

ANSWER

1 OR HIGH

ENABLING LEARNING OBJECTIVE

ACTION: Explain how Binary Coded Decimal arithmetic instructions are used in microprocessors.

CONDITIONS: Given a classroom environment, Computer Aided Instruction (CAI) workstation, and official CMEMS reference material.

STANDARDS: Correctly answer 18 of 25 questions on how arithmetic instructions are used in microprocessors.

UNSIGNED BCD NUMBERS

UNSIGNED BCD NUMBERS ARE DECIMAL NUMBERS REPRESENTED BY ITS 4 BIT BINARY EQUIVALENT (0 - 9)

0000

0001

...

...

1000

1001

UNSIGNED BCD NUMBERS

CONVERSION

Each digit in a decimal number is represented by its four bit binary equivalent.

2 - 0010

25 - 0010 0101

548 - 0101 0100 1000

UNSIGNED BCD NUMBER ADDITION

0001 0111	17
0001 1001	19

UNSIGNED BCD NUMBER ADDITION

0001 0111	17
0001 1001	19
0011 0000	36

3
0

BCD Carry

BCD numbers are made up of four bit binary which only produce a carry when they go above 15. Decimal numbers carry when they go above 9. This creates a difference of 6.

UNSIGNED BCD NUMBER

ADDITION

DAA

Decimal Adjust the Accumulator

Adjusts the 8 bit binary number in the accumulator into two 4 bit BCD digits.

It adds 6 to the answer of the equation if it exceeds 9 or the Auxiliary Carry Flag has been set by the addition.

Should always follow an ADD command.

UNSIGNED BCD NUMBER ADDITION

0001 0111	17
0001 1001	19
0011 0000	36
0110	
0011 0110	36

UNSIGNED BCD NUMBER SUBTRACTION

0100	0100	44
0010	1000	28
0001	1100	16
1	C	

UNSIGNED BCD NUMBER SUBTRACTION

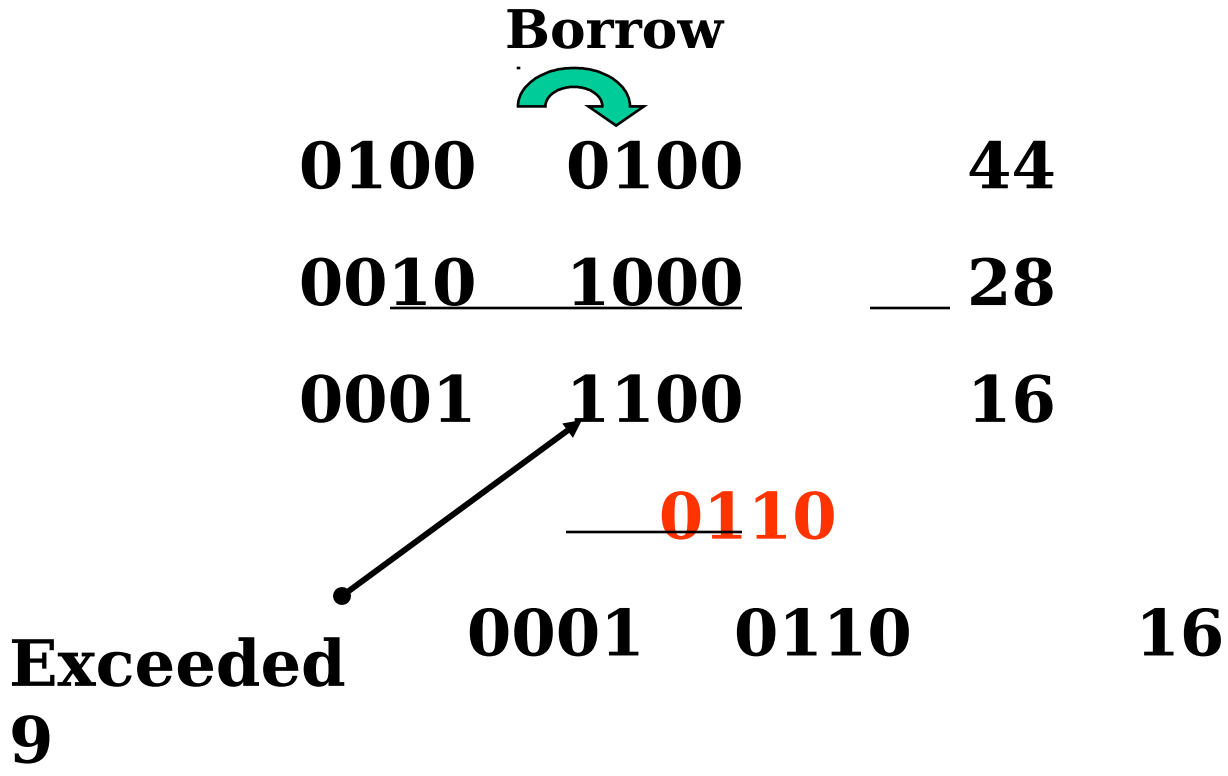
DAS

Decimal Adjust for Subtraction

Converts the binary number to its BCD form. It then subtracts 6 from the answer if it exceeds 9 or if the Auxiliary Carry Flag is set.

It must always follow a SUB command.

UNSIGNED BCD NUMBER SUBTRACTION



SIGNED BCD NUMBER ADDITION

SIGNED BCD NUMBERS

When adding negative BCD numbers use the 10's complement.

To take the 10's complement 100 is added to the negative number ignoring any carries out of the second digit.

Negative Decimal Number

-81

= 19

100 + (-81)

10's complement

SIGNED BCD NUMBERS

If one of the signed BCD numbers is negative then it must be converted to the 10's complement.

If there is no carry then the answer must be 10's complemented and is negative.

If there is a carry, the carry is dropped and the answer is positive.

-43
+32
-11

100 + (-43) = 57

+32
89

10's complement
100 – 89 = 11

-11

-43
+5
2 9

100 + (-43) = 57

+52
10
9

Drop carry ⟶ **9**

SIGNED BCD NUMBERS

If both of the signed BCD numbers are negative then they must be converted to the 10's complement.

The carry is dropped and the answer is 10's complemented and is negative.

-58
-16
-74

100 + (-58)
100 + (-16)
100 + (-74)
42
84
126

Drop carry & 10's complement

100 -26 = 74

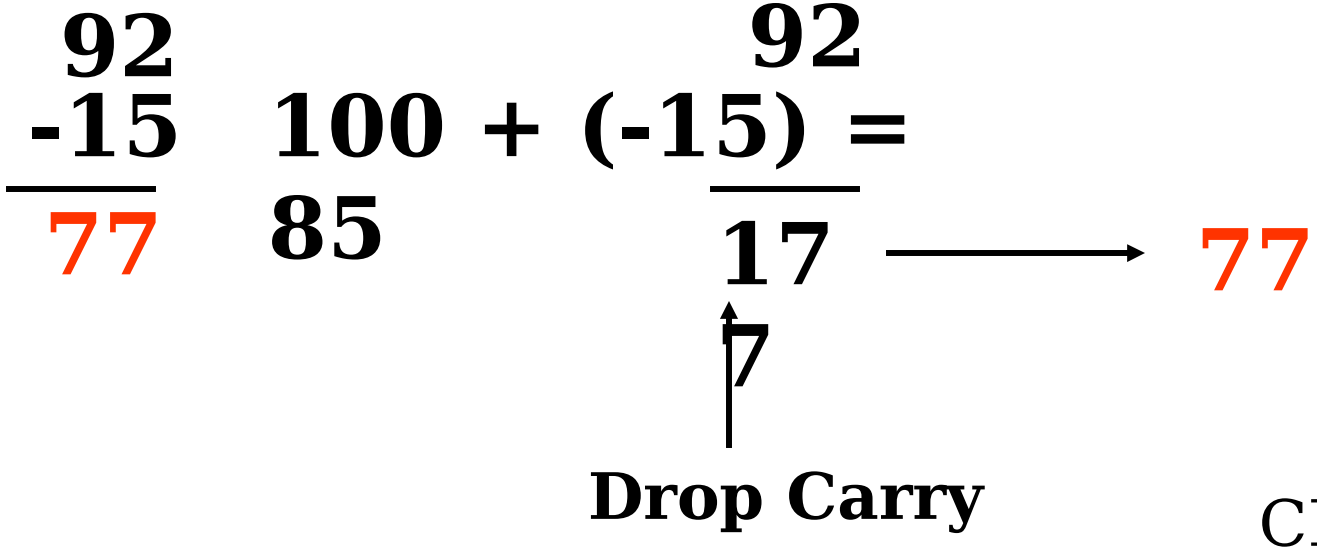
-74

SIGNED BCD NUMBER SUBTRACTION

SIGNED BCD NUMBER

SUBTRACTION

Signed BCD numbers are subtracted by adding the 10's complement and dropping any carries. The answer is not complemented.



QUESTION

When should a DAA command be performed?

ANSWER

Immediately after a BCD addition.

QUESTION

What conditions will cause the DAS command to subtract 6 from a BCD number?

ANSWER

The BCD number is more than 9 or the Auxiliary Carry flag is set.

ENABLING LEARNING OBJECTIVE

ACTION: Program computer arithmetic operations.

CONDITIONS: Given a classroom environment, Computer Aided Instruction (CAI) workstation, and official OMEMS reference material.

STANDARDS: Correctly answer 18 of 25 questions on how arithmetic instructions are used in microprocessors.

PE

CAI - ADVANCED ELECTRONICS /MICROPROCESSOR SOFTWARE/ARITHMETIC INSTRUCTIONS.

LESSON BOOK - BLOCK 1, LESSON 1, EXERCISES 1-10 AND EXPERIMENT PART 2.

ENABLING LEARNING OBJECTIVE

ACTION: Perform computer arithmetic operations.

CONDITIONS: Given a classroom environment, Computer Aided Instruction (CAI) workstation, and official OMEMS reference material.

STANDARDS: Correctly answer 18 of 25 questions on how arithmetic instructions are used in microprocessors.